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The research topics carried out under this contract are stated and references are given to the publications of the scientific findings resulting from the research. The personnel supported by the contract are listed.		



ATOMIC AND MOLECULAR PROCESSES IN  
ATMOSPHERIC ENVIRONMENTS

ARPA Order No. 826  
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Final Report

by

Manfred A. Biondi

September 11, 1975

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University of Pittsburgh  
Pittsburgh, Pa. 15260



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## I. Summary of Research

During the period of this contract, April 26, 1966 to June 30, 1975, research was carried out in the following areas of atomic collisions and upper atmosphere studies:

### A. Laboratory Studies

1. Radiative Properties of Simple Molecules for Optical Discrimination Studies
2. Clean Air Chemistry and Chemiluminescence
3. Sodium Ion and Other Reactions
4. Processes Involving Metastable Species
5. Ion Molecule Reactions and Excitation Processes in a Fast Flow System
6. Ion Molecule Reactions at Elevated Temperatures
7. Electron Attachment to Metal Oxides
8. Attachment of Electrons to Hot Oxygen
9. Crossed Beam Studies of Radiating State Excitation by Vibrational Energy Transfer
10. Reactions of Metal Atoms with Ions in Magnetically Confined  $\text{NO}^+$  Plasmas
11. Afterglow Studies of the Excitation of Radiating States by Vibrational Energy Transfer: Optical Pumping Experiments
12. Coincidence Scattering Experiments
13. Internal Energies of Photodissociation Products
14. Time of Flight Experiments
15. Laser Ion-Molecule Reaction Rates
16. Particulate Technology
17. Kinetic Energy of Excited Metal Atoms in Chemical Reactions
18. Neutral-Neutral Reactions in Crossed Beams
19. Energy Partitioning in Metal Atom Chemi-Excitation
20. Processes Involving Metastable Species

21. Dissociative Excitation of  $\text{CO}(A^1\Pi)$  by Electron Impact on  $\text{CO}_2$
22. Infrared Emission From Recombination and Energy Transfer Process of Air Species

B. Theoretical Studies

1. Semi-Empirical Methods for Estimating Reaction Rates
2. Ionization and Excited State Populations in Barium Plasmas
3. Resonance Line Profiles in Alkali Vapors
4. Quantum Theory of Dissociative Recombination Rates
5. Pseudopotential Studies of Atoms and Molecules
6. Low Energy Atom-Atom Collision Cross Sections
7. Formal Collision Theory
8. Auger and X-ray Spectra
9. Energy Distribution in Ion Drift Tubes

C. Ground Based Observations, Rocket and Satellite Measurements

1. Airglow Interferometry
2. Optical Interferometric Studies of Barium Releases
3. Auroral Interferometry
4. Optical Photometer Studies of Nightglow Ionospheric Modifications
5. Measurements of the Ionized and Neutral Constituents of the Atmosphere

D. Model Calculations of Atmospheric Composition and Response

1. Composition of the Mesosphere and Lower Thermosphere
2. Distribution of Gases in the Mesosphere

E. Informal Workshop on Atmospheric Metastables and Infrared Emitters

II. Research Publications Produced Under the Contract

The following is a list of the scientific publications which set forth the results of research of interest to ARPA carried out during this period and in many cases supported under this contract.



### Publications

- "Negative Ions of  $N_2O$  and  $CO_2$ ", J. N. Bardsley, J. Chem. Phys. 51, 3348, 1969.
- "Temperature Dependence of Dissociative Recombination", J. N. Bardsley, Phys. Rev. A2, 1359, 1970.
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- "Calculation of the Width of Narrow Shape Resonances", R. A. Bain and J. N. Bardsley, J. Chem. Phys. 55, 4535, 1971.
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- "Excitation of Atomic Nitrogen by Electron Impact", E. J. Stone and E. C. Zipf, J. Chem. Phys. 58, 4278, 1973.

### III. Personnel Supported by this Contract

The following personnel have received partial or total support under this contract.

#### Faculty Members:

J. N. Bardsley  
M. A. Biondi  
R. T. Brackmann  
T. M. Donahue  
W. L. Fite  
E. Gerjuoy  
F. Kaufman  
E. C. Zipf

#### Post-Doctoral Personnel:

J. G. Anderson  
W. Borst  
J. W. Bozzelli  
R. B. Cohen  
E. Enemark  
F. Faisal  
A. Farragher  
T. Finn  
J. Fricke  
R. Gann  
J. D. Garcia  
J. Geddes  
M. F. Golde  
B. Guenther  
R. Gutchek  
R. D. Hake, Jr.  
W. R. Henderson  
R. Johnsen  
B. R. Junker  
J. B. Kumer  
H. H. Lo  
J. Mehr  
R. Myer  
H. Nakamura  
R. Nieman  
G. Nutt  
A. Roche  
H. W. Rundel  
V. B. Sheorey  
D. P. Sipler  
D. E. Shemansky  
A. I. Stewart  
E. Stone  
S. Studniarz  
P. J. Teubner  
B. K. Thomas  
R. Thomas  
G. Unger  
W. C. Wells



## Visiting Faculty:

R. Bassel  
W. Jackson  
H. B. Palmer  
P. Stone

## Graduate Research Assistants:

R. A. Bain  
V. M. Bierbaum  
D. Brocklebank  
H. L. Brown, Jr.  
P. Buchwalter  
B. Carnahan  
R. Castell  
Y. P. Chong  
L. Clendenning  
R. Cody  
V. Donnelly  
N. Dorn  
P. Erdman  
R. Fralick  
R. J. Girnius  
B. Guenther  
R. Gutcheke  
R. D. Hake, Jr.  
J. M. Heimerl  
C. M. Howard  
W. E. Kauppila  
B. Kim  
H. Krause  
J. B. Kumer  
L. Kurzweg  
D. Lessie  
S. Levine  
S. C. Liu  
H. H. Lo  
J. L. McCrumb  
R. McLaughlin  
J. J. Margitan  
M. Mumma  
R. Myer  
R. Nieman  
W. R. Ott  
J. Peden  
J. Ross  
S. Sinha  
D. P. Sipler  
C. V. Sukumar  
H. Tai  
B. K. Thomas  
G. Unger  
B. Wasser  
C. S. Weller  
T. Zajdel

IV. Degrees Awarded

C. S. Weller	Ph.D. 1967
James Peden	M.S. 1967
J. Casalese	M.S. 1968
N. Dorn	M.S. 1968
George A. Doschek	Ph.D. 1968
J. M. Heimerl	Ph.D. 1968
W. R. Ott	Ph.D. 1968
J. W. Philbrick	Ph.D. 1968
B. Guenther	M.S. 1969
W. Kauppila	Ph.D. 1969
J. B. Kumer	Ph.D. 1969
Hsi-Hu Lo	Ph.D. 1969
T. Parkinson	Ph.D. 1969
R. Fralick	Ph.D. 1970
R. D. Hake, Jr.	Ph.D. 1970
H. F. Krause	Ph.D. 1970
L. Kurzweg	Ph.D. 1970
M. Munma	Ph.D. 1970
H. Tai	Ph.D. 1970
Kwang Ok Yeo	M.S. 1970
L. M. Clendenning	Ph.D. 1971
B. Guenther	Ph.D. 1971
R. A. Gutcheck	Ph.D. 1971
C. J. Howard	Ph.D. 1971
R. Nieman	Ph.D. 1971
J. L. McCrumb	Ph.D. 1971
D. P. Sipler	Ph.D. 1971
R. Cody	Ph.D. 1972
N. Poeth	Ph.D. 1972
B. K. Thomas	Ph.D. 1972
R. J. Girnius	Ph.D. 1973
S. Z. Levine	Ph.D. 1973
R. L. Myers	Ph.D. 1973